Asset bubbles in shipping?
An analysis of recent history in the drybulk market

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ABSTRACT

The purpose of this paper is to investigate the hypothesis that the supercycle in the drybulk freight market between 2003 and 2005 caused asset values in the second-hand market to deviate from underlying fundamentals. We test the instantaneous equilibrium relationship between the actual second-hand values and those implied by the newbuilding and freight market conditions in a Vector Error Correction Model (VECM) framework. We also estimate and account for, for the first time, the time-varying delivery lag in the newbuilding market. Our empirical results suggest that the second-hand market was closely cointegrated with the fundamental freight and newbuilding market with no evidence of a short-term asset "bubble"

Keywords: Newbuilding prices, second-hand market, asset bubble, market integration

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1. INTRODUCTION

The global shipping market has long been defined to be comprised of four separate but interrelated markets (Stopford, 1997): the newbuilding market where ships are ordered and built; the freight market where ships are chartered, the sale and purchase market for second-hand tonnage, and the demolition market where ships are scrapped as they reached the end of their useful economic life. Wijnolst and Wergeland (1996) offer an alternative classification of shipping markets, distinguishing between the "real" markets for ships (demolition and newbuilding) and spot freight and the "auxiliary" markets for timecharters and second-hand ships, given that the latter two do not influence the total supply of transport. In either case, because the same shipowners are trading in all markets, the dynamics of these markets are closely interrelated.

Much of the maritime economic literature of the 1980s was devoted to the simultaneous modeling of some or all of these basic shipping markets in an equilibrium framework (see, for instance, Charemza and Gronicki, 1981; Norman and Wergeland, 1981; Wergeland, 1981; Beenstock, 1985; Strandenes, 1986; Beenstock and Vergottis, 1989). In these research works, the perfect integration of the shipping markets was often assumed, if only implicitly. For instance, Beenstock (1985) assumes that new and second-hand ship prices are perfectly correlated, though he observes that this condition is unlikely to hold because newbuilding prices are "sticky" compared to second-hand prices. In subsequent work (Beenstock and Vergottis, 1989), this stringent assumption is relaxed by separate dynamic modeling of the newbuilding market. In Strandenes (1984, 1986) the newbuilding price links the newbuilding and second-hand markets by defining the long-run expected earnings of a vessel and, consequently, the second-hand value as a weighted average of short and long-term profits. Tsolakis, Cridland and Haralambides (2003) investigate second-hand prices in an Error Correction Model with a theoretical basis and find that newbuilding prices and timecharter rates are the main drivers. The remainder of the literature takes a partial equilibrium approach and considers the price dynamics and market efficiency in each shipping market (as defined above) in isolation. For instance, Hale and Vanags (1992), Glen (1997) and Veenstra (1999) investigate market efficiency in the second-hand market on the basis of cointegration analysis, while Kavussanos (1996a, b, 1997) considers the modeling of time-varying volatility for different ship sizes in the drybulk and tanker markets.

In this paper we extend the literature in two important ways. Firstly, we propose a methodology to estimate and include the time-varying delivery lag in the investigation of asset dynamics. Secondly, we investigate whether observed second-hand prices are consistent with the implied asset prices from a theoretical instantaneous equilibrium relationship between the four shipping markets. Using the Capesize drybulk ship market as an empirical example, this enables us to draw conclusions about the existence of an asset bubble during the 2003 – 2005 supercycle in the drybulk freight market.

The remainder of the paper is organized as follows: Section 2 presents the methodology and the estimation of the time-varying delivery lag in shipping. Section 3 presents the cointegration and Granger causality analysis and Section 4 concludes.

2. THE TIME-VARYING DELIVERY LAG

We base our empirical analysis on the theoretical results in Adland and Jia (2006) who show that the instantaneous equilibrium between the four shipping markets (i.e. the freight, demolition, second-hand and newbuilding markets), under the assumption of linear depreciation of vessels, can be expressed by the following relationship:

$$S_{t,0} = I_{t,t} + F_{t,t}\,\frac{(T_t - t)}{T_t} + \frac{Z_t \cdot t}{T_t}\,\frac{1}{(1 + r_{t,t})^{t-t}} \qquad (1)$$

where

- $S_{t,0}$ is the price of vessel of age zero at the current time t
- t is the time at which a ship contracted today is delivered (i.e. $t - t$ is the delivery lag).
- $I_{t,t}$ is the net present value of net profits from a timecharter between t and t.
- $F_{t,t}$ is the net present value at time t of payments to the shipyard according to a newbuilding contract for a ship delivered at time t.
- T_t is the life expectancy of ships at time t.
- Z_t is the prevailing scrap value of a standard ship and
- $r_{t,t}$ is the risk free interest rate for maturity $t - t$.

It follows that if we know, for instance, the current value of a new vessel $S_{t,0}$, the applicable timecharter rate and the scrap value Z_t, we can derive the theoretically consistent newbuilding contract value $F_{t,t}$. This derived time series can then be compared with observed market prices to draw inference about the degree of market integration over time. We use this approach in the empirical investigations below.

Importantly, Equation 1 correctly accounts for the impact of the time-varying delivery lag $(t - t)$, a feature that has not received sufficient attention in the maritime economic literature. The actual delivery time between the contracting date and handover is instead largely decided by the availability of time slots in the drydock facilities of the individual yard, which again depends on the size and composition of its orderbook and the bargaining power of the customer. However, subject to differences in quality and customisation, the competitive nature of the shipbuilding market and the dissemination of information by newbuilding shipbrokers means that contracting prices and chronological slot availability do not differ much among the main shipbuilding groups in the Far East[1]. It is worth emphasising that the different types of ships will compete for the same slots, and so the delivery lag for bulk carriers, for instance, will be influenced by the demand for other ship types such as tankers and gas carriers. The data used in this study suggests that there is no clear relationship between the size of the ship and the delivery lag, presumably as smaller vessels will tend to be built by smaller less efficient yards. It follows from the above that estimates of the time-varying delivery lag should be based on the entire orderbook across vessel types and shipyards, but with a focus on a particular size range for the sake of consistency.

For the purpose of our empirical estimation of the time-varying delivery lag, Clarkson Research Studies kindly provided panel data including the deadweight, ship

[1] A possible exception is Japan, where information about contracts between domestic yards and shipowners are often withheld from the market until near delivery of the ship. This could lead to underestimation of the actual delivery lag.

type, contracting date, delivery date, shipyard name and builder country for ships built or on order in the main shipbuilding nations (Japan, South Korea and China) as of October 1, 2005. From this data sample we extract all vessels between 100,000 and 200,000 DWT for which both the contracting date and delivery date is known, leaving a total of 1,081 observations for ships ordered between January 1994 and October 2005. Table 1 below summarises the sample averages of the delivery lag by vessel type and builder nation. We note that Japan appears to be the most efficient shipbuilder for this particular size of ships, followed by South Korea and China. Moreover, bulk carriers have, on average, the lowest delivery lag, followed by tankers, other vessels such as offshore vessels and gas carriers, and container ships. This reflects roughly the degree of technological sophistication, with bulk carriers being by far the simplest vessels to build.

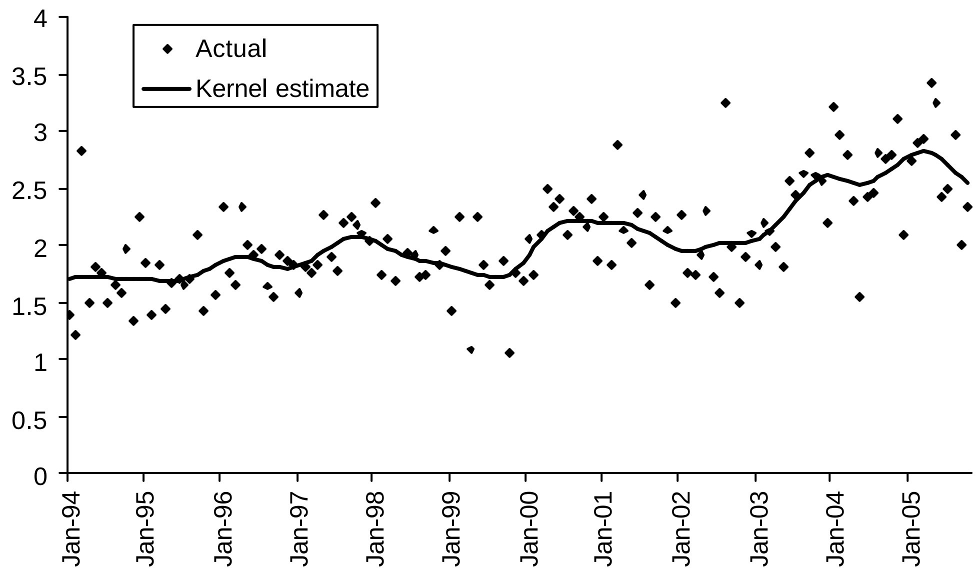
Table 1: Delivery lag descriptive statistics

Builder Country	Vessel type	No. obs	Average delivery lag
China P.R.	Bulk Carrier	45	2.32
	Container	5	3.52
	Tanker	38	2.58
	Total	88	2.50
Japan	Bulk Carrier	187	1.86
	Other	2	2.46
	Tanker	197	2.12
	Total	386	1.99
South Korea	Bulk Carrier	111	1.90
	Container	81	2.78
	Other	24	2.51
	Tanker	391	2.21
	Total	607	2.24
Overall	Bulk Carrier	343	1.93
	Container	86	2.83
	Other	26	2.51
	Tanker	626	2.20
	Total	1081	2.17

Includes vessel between 100,000 and 200,000 dwt only
Delivery lead time measured in years

Turning next to the dynamic nature of the delivery lag we plot in Figure 1 below the average delivery lag (actual or, for vessel on order, projected) for all vessels ordered in a given month together with the Kernel regression estimate of the time-varying delivery lag. The Kernel regression (see Hardle, 1990, for technical details) is based on a local linear estimator with Gaussian Kernel function and a bandwidth of 3 months. The estimation is performed with the standard econometrics software Eviews. Of particular note in Figure 1 is the cyclicality of the average delivery lag as well as is the increase in the delivery lag following the extremely strong freight market across sectors in the period 2003 - 2005. The kernel estimate is used as the time series of the time-varying delivery lag (t – t) in the subsequent empirical work.

Figure 1: Time-varying delivery lag estimate (100 – 200K DWT)

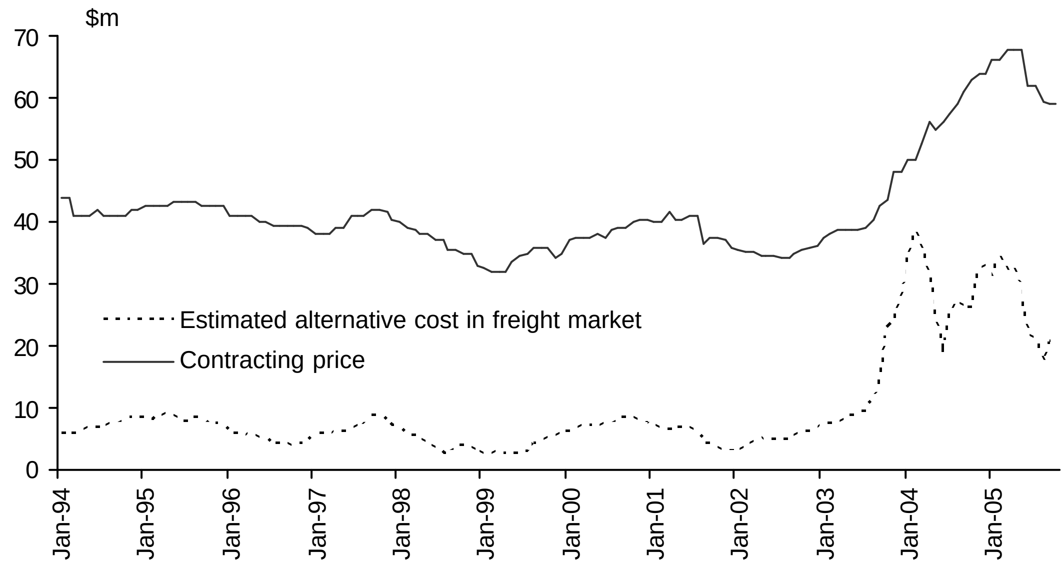


3. EQUILIBRIUM ANALYSIS

Having established the dynamics of the time-varying delivery lag, we can next turn our attention to the empirical estimation of the theoretical second-hand implied from prices in the freight and newbuilding markets as per Equation 1. For this purpose we chose to investigate the Capesize bulk carrier sector, which falls into the size range investigated above (historically 120,000 – 175,000 DWT depending on year of build). Clarkson Research Services provided monthly time series of contracting prices, second-hand prices for five-year old vessels, and the one and three-year timecharter rates for the period January 1994 through October 2005, as well as annual average scrapping age (as our proxy for expected lifespan). The timecharter rates for intermediate durations are found by linear interpolation. The risk free interest rate is taken to be the constant-maturity one-year T-Bond rate provided in the US Federal Reserve Bank Statistical Release H.15. Capesize operating costs are assumed to be constant and equal to $5,500/day. Payments to shipyards are assumed to be 20% of the contracting price upon signing the contract and 80% upon delivery.

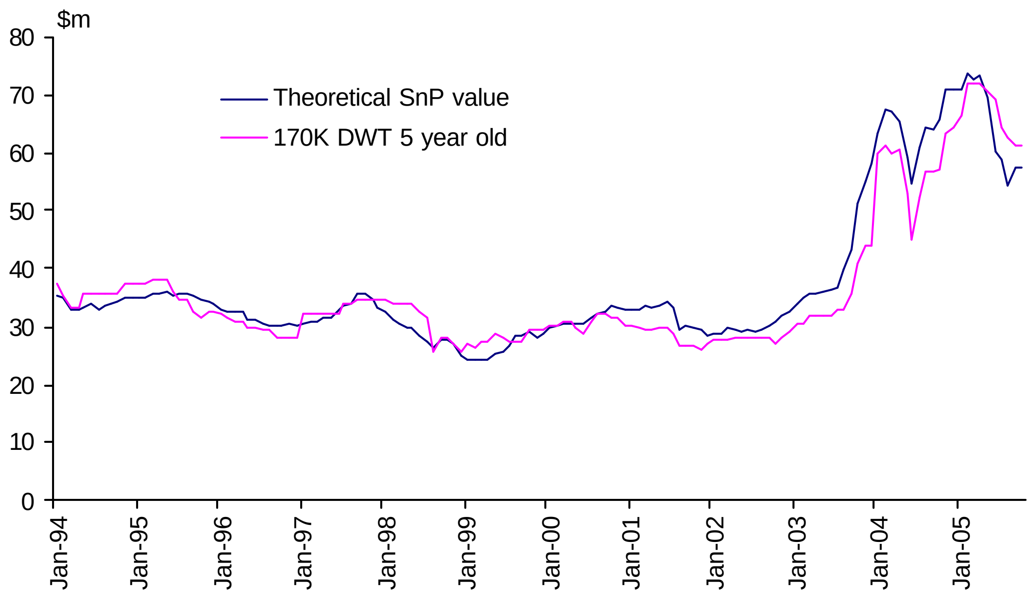
Figure 2 below illustrates the dynamics of the resulting alternative cost in the freight market incorporating the time-varying delivery lag as per Equation 1 along with the observed newbuilding contracting price. Of note is the fourfold increase in the alternative cost ($I_{t,t}$) from operation in the freight market in the second half of 2003, termed as the start of the drybulk market "supercycle", followed by the much slower appreciation in Capsize newbuilding prices.

Figure 2: Estimated alternative cost in the freight market



The corresponding implied second-hand value for a five-year old Capesize vessel (as per Equation 1 and adjusted for age using linear depreciation) is shown in Figure 3 below.

Figure 3: Actual versus implied second-hand values



While it is evident from Figure 3 that the second-hand market has been highly integrated with the freight and newbuilding market, we proceed to formally test cointegration. The long-run relationship between the empirical and theoretical second-hand prices is investigated within the cointegration framework developed by Engle and Granger (1987). In particular, we employ the Johansen (1991, 1995) cointegration testing techniques based on a Vector Error Correction model (VECM), which governs the joint behaviour of y_{t1} (the empirical price) and y_{t2} (the theoretical price) over time as:

$$\Delta Y_t = A + \sum_{i=1}^{p-1} \Gamma_i \Delta Y_{t-i} + \Pi \cdot Y_{t-1} + e_t \tag{2}$$

where Y_t is a $n \times 1$ vector of the endogenous variables and Y_{t-1} is the error correction term. To expand it, the VECM can be expressed in the following form:

$$\begin{pmatrix} \Delta y_{t,1} \\ \Delta y_{t,2} \end{pmatrix} = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix} \cdot \begin{pmatrix} \Delta y_{t-1,1} \\ \Delta y_{t-1,2} \end{pmatrix} + \begin{pmatrix} a_1 \\ a_2 \end{pmatrix} \cdot (y_{t-1,1} - b \cdot y_{t-1,2}) + \begin{pmatrix} e_1 \\ e_2 \end{pmatrix} \tag{3}$$

The cointegration relationship is tested based on the rank of the parameter matrix Π, i.e. the coefficient of the error correction term. If rank (Π) = 0 then Π is of dimension $n \times n$ implying that there is no cointegration relationship. If rank (Π) = n then all the variables are $I(0)$ and the VECM is reduced to a VAR model. If rank (Π) = k ($0 < k < n$) there are k cointegration relationships among the variables Y_t. Hence Π can be divided into two components: $\Pi = \mathbf{a} \cdot \mathbf{ß}'$, where a is a $n \times k$ metrics of error correction coefficients and b is a $k \times n$ metrics of cointegrating parameters (vectors). The coefficients $\boldsymbol{a}$ denotes the speed of adjustment of the variables toward the equilibrium when there are deviations. Johansen's (1991, 1995) method considers two test statistics. The first test is a trace test in which the null hypothesis is that the rank of ? is less than or equal to r cointegrating vectors and the trace statistic is computed as:

$LR_{tr}(r \mid k) = -T \sum_{i=r+1}^{k} \log(1 - l_i)$	(4)

where $?_i$ is the i^{th} largest Eigenvalue of Π matrix.

The second test in Johansen (1991, 1995) method is the max-Eigenvalue test with the null hypothesis of r cointegration relations against the alternative or r+1 cointegration relations and the statistic is calculated as:

$LR_{\max}(r \mid r+1) = -T \log(1 - l_{r+1}) = LR_{tr}(r \mid k) - LR_{tr}(r+1 \mid k)$	(5)

The distributions for these tests are not given by the usual chi-squared distributions. Rather, the asymptotic critical values for these likelihood ratio tests are calculated via numerical simulations (see Johansen and Juselius 1990; and Osterwald-Lenum 1992). The lag length i is determined by the standard Schwarz Criteria (Schwarz, 1978). The estimation results of the cointegration test and the VECM are shown in Table 2. It is found that the empirical and theoretical second-hand prices are cointegrated, with the cointegration vector being (1, -0.9838) at the 5% significance level based on both the Trace test and max-Eigenvalue test, suggesting that the empirical and theoretical prices move very closely on a nearly one-to-one basis.

Table 2: Cointegration between theoretical and empirical second-hand prices

Panel A: Cointegration test			
	Eigenvalue	Trace statistics	Max-Eigen Stat.
$H_0: r = 0; H_1: r = 1$	0.1239	18.7192 *	18.5258 *
$H_0: r = 1; H_1: r = 2$	0.0014	0.1933	0.1933

Panel B: the estimation results of the VECM

$$\begin{pmatrix} \Delta y_{t,1} \\ \Delta y_{t,2} \end{pmatrix} = \begin{pmatrix} r_{11} & r_{12} \\ r_{21} & r_{22} \end{pmatrix} \cdot \begin{pmatrix} \Delta y_{t-1,1} \\ \Delta y_{t-1,2} \end{pmatrix} + \begin{pmatrix} a_1 \\ a_2 \end{pmatrix} \cdot (y_{t-1,1} - b \cdot y_{t-1,2}) + \begin{pmatrix} e_1 \\ e_2 \end{pmatrix}$$

The cointegration vector $(y_{t1} \quad y_{t2}) = (1 \quad -0.9838)$

[-55.141]

i=1,2	r_{i1} ($\Delta y_{t-1,1}$)	r_{i2} ($\Delta y_{t-1,2}$)	a_i (ect_{t-1})
$\Delta y_{t,1}$	-0.0677 [0.377]	**0.3205** [0.064]	**-0.2403** [0.038]
$\Delta y_{t,2}$	0.0556 [0.599]	0.2698 [0.109]	**-0.1269** [0.093]

- $H_0: r = 0; H_1: r = 1$ represents the null hypothesis of no cointegration relationship;
- $H_0: r = 1; H_1: r = 2$ represents the null of one cointegration relationship
- * represents the rejection of the null at the 5% significance level.
- Figures in brackets [ ] are *p*-values; Figures in bold are statistically significant at the 10% level.
- It assumes no deterministic trend in the cointegration relationship;
- The 5% critical values: (CE = Cointegration equation)

	None CE	At most 1 CE
Trace	12.53	11.44
Max-Eigen	3.84	3.84

4. CONCLUDING REMARKS

Figure 3 and the above cointegration tests shows that the "auxiliary" second-hand market has been closely integrated with the fundamentals in the "real" markets for freight and newbuildings over the time period investigated and, therefore, that no asset bubble existed despite the doubling of prices in a short space of time in 2003. We note in particular that the development in the observed second-hand price appears to have lagged the fundamental equilibrium price during this time period and never reached the record levels set by the latter in January 2004.

This short-run deviation, suggesting that second-hand prices actually were undervalued at the time (the opposite of an asset "bubble"), could have at least two competing explanations. Firstly, it is likely, despite our finding of a high degree of integration, that our theoretically derived second-hand price suffers from measurement error in the underlying data and imposed by our assumptions. In particular, we have assumed that the term structure of freight rates is linear between the one and three-year maturities. In practice, as documented by Koekebakker and Adland (2004), the term structure of drybulk freight rates can take on many shapes (e.g. it is most often hump shaped), some of which will imply non-linearity. Furthermore, empirical results in Adland, Koekebakker and Sodal (2004) suggest that the relationship between ship values and age can also be non-linear, particularly near the scrapping age. The assumption that the expected lifespan of a ship equals the observed prevailing average scrapping age may also be inappropriate, though we would be hard pressed to come up with a better empirical proxy.

Secondly, the apparent under valuation of second-hand values during the initial stages of the drybulk supercycle may rationally reflect the default risk inherent in timecharter contracts (or equivalently freight derivative contracts) entered into at the top of the market (cf. Adland and Jia, 2005). The presence of default risk would lower the expected net present value of the "alternative cost" from operating an existing ship in the freight market and therefore lower the theoretically implied asset value compared to our estimates. The fact that timecharters may not always be available in practice, thus leaving the investor with a speculative investment at the top of the market, would have the same effect. The observed apparent mispricing in the second-hand market may therefore be entirely rational.

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